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ABSTRACT

An experiment was carried out to determine how the memory search of a two-clause complex sentence in immediate memory is carried out. An item-recognition task was performed with 32 native English-speaking, right-handed adults who listened to eight two-clause complex sentences presented to the left ear, each immediately followed by a probe word presented to the right ear. The subjects indicated whether or not the probe word occurred in the sentence, and their recognition latency was measured. An analysis of variance was performed on recognition latency as a function of the three independent variables: (1) the serial position of the target word, early or late, within (2) a main or subordinate clause, in (3) initial or final clause position. The findings of this experiment were: (1) a word in the final clause is recognized significantly faster than a word in the initial clause; (2) for subordinate clauses, subjects take longer to respond to a target word occurring late in the clause than to a target word occurring early in the clause; for main clauses, subjects take longer to respond to a target word occurring early in the clause than to a target word occurring late in the clause. Present storage models of sentence processing and memory search models are inadequate to account for all the data. A combined storage-search account is proposed. (Author/CFM)

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Memory-Scanning of a Complex Sentence Just Heard[1]

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Abstract

The following question was posed: How is the memory search of a two-clause complex sentence in immediate memory carried out? An item-recognition task was performed with 32 native English speaking, adult, right handed subjects who listened to eight two-clause complex sentences presented to the left ear, each immediately followed by a probe word presented to the right ear. The subjects indicated whether or not the probe word occurred in the sentence and their recognition latency was measured. An analysis of variance was performed on recognition latency as a function of the three independent variables: (a) the serial position of the target word, early or late, within (b) a main or subordinate clause, in (c) initial or final clause position. The findings of this experiment were: (a) a word in the final clause is recognized significantly faster than a word in the initial clause; (b) for subordinate clauses, subjects take longer to respond to a target word occurring late in the clause than to a target word occurring early in the clause; for main clauses, subjects take longer to respond to a target word occurring early in the clause than to a target word occurring late in the clause. Present storage models of sentence processing and memory search models are inadequate to account for all the data. A combined storage-search account was proposed. A serial self-terminating model of clause accessing, with final clause search occurring prior to initial clause search, fit the data better than a simultaneous search of both clauses. Clauses are searched either in a primary or a secondary buffer, depending on clause type (main or subordinate) and clause position (initial or final) in the sentence. To explain the difference in mode of search between main and subordinate clauses, it was suggested that main clauses exhibit a property of primacy over subordinate clauses.

How is the memory search of a two-clause complex sentence in immediate memory carried out? Some investigators have used a real time procedure, the item-recognition task, in an attempt to describe the way in which a list of items in immediate memory is scanned for recognition (Clifton & Birenbaum, 1970; Corballis, 1967; Morin, DeRosa, & Stultz, 1967; Sternberg, 1966, 1969). In the item-recognition task, subjects are presented with a set of stimuli, often digits, to be memorized, followed by a test stimulus (test digit or probe). The subject is to decide whether or not the probe occurred in the stimulus set and to respond as quickly and as accurately as possible. The reaction time from probe onset to response is recorded as the dependent variable and is taken to imply the nature of the mental operations involved (for a discussion of search procedures, see Sternberg, 1969). It is not clear whether memory-scanning for recognition of list items is best described as a serial process, in which internal items are scanned one at a time, or a parallel process, in which items are scanned simultaneously. Sternberg (1966, 1969) has maintained that recognition of list items is accomplished by means of an exhaustive serial search; i.e., after all the items are searched one at a time, a response is made. An exhaustive serial search entails a flat curve for mean RT by serial position. Morin, DeRosa, and Stultz (1967) and Corballis (1967), however, have produced item-recognition task data showing a recency effect. Sternberg (1969) noted that in item-recognition experiments which showed a recency effect the interval between the last list item and the probe (probe delay) was less than 1 second. Clifton and Birenbaum (1970) found that with short probe

delays (within about 1 second) the RT serial position curve showed a recency effect, but was flat at longer delays. Their finding suggested that the primacy of memorized items may affect the shape of the serial position curve.

In some item-recognition studies subjects were asked to indicate whether or not a probe word occurred in a two-clause complex sentence just heard (Caplan, 1971, 1972; Kornfeld, Note 1). One might suppose that in searching for a word in a sentence just heard the subject simply "reads" the sentence out of memory much as it is spoken, i.e., in the order first word of the sentence, second word, and so on until a match between the probe word and the target word is found and a positive response is given, or no match is found and a negative response is given (serial self-terminating search in order of presentation). However, there is reason to believe that this is not the case in any simple way. A number of studies have found that words in the initial clause of a two-clause complex sentence are significantly more difficult to retrieve from immediate memory than words in the final clause; initial clause words are recalled less often and are recognized less rapidly than final clause words, where serial position from the end of the sentence was held constant. Jarvella (1970) demonstrated that free recall for words located prior to the clause boundary was significantly poorer than for words located after the clause boundary; that initial clause words were responsible for 80% of all errors, while final clause words were responsible for 3% of the errors. Jarvella and Herman (1972) found that the words of the final clause are recalled significantly more often than the words of the initial

clause. In addition, they found an interaction for clause position (initial vs. final) and clause type (main vs. subordinate). A main clause in final position is recalled significantly better than a main clause in initial position; in recall from subordinate clauses there is no difference between initial versus final position. These findings were not entirely consistent with the "immediate clause hypothesis" proposed by Jarvella (1970), namely, that upon hearing a sentence, a constituent structure is stored in memory until a semantic interpretation of the immediate clause is assigned. Storage of a subsequent constituent structure interferes with the verbatim recall of the previous clause. To explain why clause position affected recall from main clauses but did not affect recall from subordinate clauses, Jarvella and Herman (1972) speculated that there was a ". . . more rapid and natural interpretation of main clauses in the initial position of sentences and of subordinate clauses in the final position. To put it the other way, listeners' more delayed interpretation of material in sentences with subordinate-main clause order would tend to leave them more superficially (and fully) represented in memory" (p. 383).

Bever, Garrett, and Hurtig (1973) found that sentence completion of incomplete clauses with underlying ambiguity takes significantly longer than for unambiguous controls. However, between ambiguous and unambiguous complete clauses RT for sentence completion does not differ significantly. They suggested that at the end of a clause a semantic interpretation is assigned and the external form of the clause

is dropped.

To discover if the clause boundary affects recognition memory, Caplan (1971, 1972) employed two-clause sentences, all subordinate-main clause order, in an item-recognition task with a target word either the last word of the initial clause or the first word of the final clause. He presented sentences of this form:

1a. Now that artists are painting in oil, prints are rare.

1b. Now that artists are working fewer hours, oil prints are rare.

The subjects heard a sentence, a tone, and then a probe word; probe delay was 150 milliseconds. The subjects indicated whether or not the probe occurred in the sentence and the time from onset of the probe to response was measured. Caplan found that for probes corresponding to the target word of the terminal clause mean RT is significantly faster than for probes corresponding to the target word of the immediately preceding clause. He performed a second identical study except that probes were presented visually, and again found that mean RT for probes from the final clause is significantly faster than for probes from the preceding clause. Kornfeld (Note 1) asked whether the boundary effect found by Caplan with subordinate-main sentences would also be found with main-subordinate sentences. She employed sentences designed as follows (X = target word):

2a.	_____X,	_____.	2c.	_____X,	_____.
	subordinate	main		main	subordinate
2b.	_____, X_____.		2d.	_____, X_____.	
	subordinate	main		main	subordinate

For both clause orders, Kornfeld found the boundary effect--that subjects take significantly longer to recognize a word in the initial clause than in the final clause. In addition, she reported that mean RT is faster for main clauses than subordinate clauses; that when the events of both clauses are closely connected and plausible, mean RT is faster for main-subordinate order than subordinate-main, the "dominance effect."

There is general agreement in the literature that two-clause sentences are processed clause-by-clause (Abrams, 1973; Bever et. al., 1973; Bever, Lackner, & Stolz, 1969; Bever, Kirk, & Lackner, 1969; Caplan, 1971, 1972; Fodor & Bever, 1965; Garrett, 1965; Garrett, Bever, & Fodor, 1966; Holmes & Forster, 1972; Jarvella, 1970; Jarvella & Herman, 1972; Wingfield & Klein, 1970). If, however, it is correct to conclude that sentences are processed in clause units, rather than as a whole, then it is important to consider that memory-scanning within clause units may be affected by a word's serial position within the clause. Caplan[1] (1971, 1972) and Kornfeld (Note 1) confounded serial position of the target word within the clause with clause position and type (see sentences 1a - 2d). This leaves open the possibility that the difference in recognition latency between initial and final clauses may be attributed to the manner in which the clauses were scanned in memory. The inference that the difference in recognition latency between the last word of the initial clause and the first word of the final clause was due to clause position presupposes that the number of words (syllables, phonemes, etc.) in a clause does

not affect recognition latency; and that a target word's serial position within the clause does not affect recognition latency. Both of these assumptions have been shown to be false in recognition of list items. Sternberg (1966) showed that recognition latency is a direct function of list length. It was pointed out earlier that other investigators have found that with probe delays of less than approximately 1 second, the serial position of list items affects recognition latency.

One search hypothesis for the boundary effect is a parallel search of the initial and final clauses with a left-to-right serial self-terminating search within clauses (Parallel Clause Search Hypothesis). That is, the words of a clause are scanned one at a time in the order of presentation until a match between the probe and the target word is found; when a match is found, the search is terminated and a response is made. If this is going on in both the initial and final clause simultaneously, it would be expected that the earlier a target word occurs in the clause, the faster it would be recognized. It is unlikely, however, that only serial position within a clause affects recognition latency. There is reason to believe that in addition to a word's serial position within a clause, the type of clause and the order of clauses within the sentence may influence retrieval (Jarvella & Herman, 1972; Kornfeld, Note 1). Therefore, a second search hypothesis for the boundary effect is a serial self-terminating search of final and initial clauses, respectively; that is, final clause items are searched before initial clause items are searched (Serial Clause Search Hypothesis). If this is true, then the mean recognition latency for final clause words should be less than the mean recognition

latency for initial clause words. But, then, why should the order of clauses matter as Kornfeld (Note 1) found with main-subordinate order faster than subordinate-main? This finding may be accounted for if main and subordinate clauses are searched differently from one another, e.g., if main clauses show a recency effect and subordinate clauses show a primacy effect.

On intuitive grounds and generally supported by linguistic theory (Langacker, 1967), the clauses of a complex sentence may be said to be in a relation of subordination; where the subordinate clause is an embedded constituent in the main clause. Suppose that the centrality of the main clause increases its primacy relative to the subsidiary subordinate clause. It would then be expected that main clauses are processed differently from subordinate clauses. Some psychological evidence supports this position.

For example, Bever (1970) asked children ($1\frac{1}{2}$ - 3 years) to repeat sentences like 3. He reported that the children tended to repeat only

3. The elephant that likes the pig bit the cow.

one of the clauses ("the elephant likes the pig," or "the elephant bit the cow"). At about $2\frac{1}{2}$ years old the children tended to repeat the main clause rather than the subordinate clause. In a series of studies on comprehension of complex sentences with the conjunctions "before" and "after," Smith and McMahon (1970) gathered data with adult subjects which they interpreted to show that "what is asserted in the main clause of a sentence (e.g., "he sang," in "Before he danced, he sang") is more accessible than what is asserted in the subordinate clause ("he danced"), although there is no comparable

difference due to the order in which the events are mentioned. . ." (p. 274).

Based on the serial clause search hypothesis of this study, it is predicted that the words in the final or immediate clause will be recognized significantly faster than the words in the initial or previous clause. Moreover, if main clauses exhibit a gradient of primacy over subordinate clauses, it is expected that the manner of search within-clauses will differ between main and subordinate clauses (Within-Clause Search Hypothesis).

It is clear that without knowing the pattern of recognition latency within clauses, it is risky to decide on the theoretical inferences to be drawn from between-clause recognition latency. At present it is unknown what part of the RT curve is being sampled when the last position of the first clause is compared to the first position of the second clause.

What is required is an examination of item-recognition task data derived from two-clause sentences in which a test clause meets the following conditions: that it contain a word which may occupy an early or late serial position without altering the meaning of the sentence; that it can function in initial or final clause position; that it can function either as a subordinate or main clause. An item-recognition task with sentences designed on this model satisfies the following objectives: it becomes possible to determine the mean recognition latency between early and late target words within the clause, while varying clause position and/or type. Hence, the general finding in the literature, that it is more difficult to retrieve words

from the initial clause than from the final one, may be attributed to a target word's serial position within the clause, clause type, clause position, or an interaction amongst these variables. Also, it becomes possible to infer the manner in which the clause is searched from the pattern of recognition latency data. The present study attempted to accomplish these objectives.

Method

Subjects

The subjects were 32 paid volunteers at Columbia University. Subjects were right handed and native speakers of English.

Materials

Sixty-four two-clause test sentences were constructed. In each sentence, one clause met the following conditions: (a) it consisted of between nine and eleven monsyllabic words (with the exception of two disyllabic target words); (b) it contained a target word which could function in two positions without altering the meaning of the sentence; (c) it could function either as a main or subordinate clause in either initial or final position. The sole restriction for the other clause was that it satisfy condition (c). Thus, a test sentence exhibited eight alternative forms, which will be referred to as a set. The following exemplar illustrates the permutations by serial position of the target word within the clause, clause type, and clause position:

Set I.

1. Though the clowns and the trained bear were fun to watch, the man on the flying trapeze was the most breath-taking act of all.

2. Though the trained bear and the clowns were fun to watch, the man on the flying trapeze was the most breath-taking act of all.

3. The clowns and the trained bear were fun to watch, though the man on the flying trapeze was the most breath-taking act of all.

4. The trained bear and the clowns were fun to watch, though the man on the flying trapeze was the most breath-taking act of all.

5. Though the man on the flying trapeze was the most breath-taking act of all, the clowns and the trained bear were fun to watch.

6. Though the man on the flying trapeze was the most breath-taking act of all, the trained bear and the clowns were fun to watch.

7. The man on the flying trapeze was the most breath-taking act of all, though the clowns and the trained bear were fun to watch.

8. The man on the flying trapeze was the most breath-taking act of all, though the trained bear and the clowns were fun to watch.

Seven other sets of test sentences, differing in semanitic content, were constructed. In all, eight sets were used. Across sets, target words were distributed in various serial positions ranging from one eo eight syllables from the beginning of the clause.

Thirty additional sentences were constructed. Six served as practice sentences, three subordinate-main and three main-subordinate sentences. For each clause order (subordinate-main and main-subordinate), one probe was from the beginning of the sentence, one was from the end of the sentence, and one was not present in the sentence. The remaining 24 sentences served as filler sentences to vary the serial position of the target word. The filler sentences consisted of 12 subordinate-main and 12 main-subordinate sentences. For each clause order (subordinate-main and main-subordinate), four probes were from an extremely early position in the sentence, four were from an extremely late position, and four were not present in the sentence (See Appendix A for a complete listing of stimulus materials).

Design

The experimental design was a 2 X 2 X 2 factorial design; the three

independent variables were clause type (main or subordinate), clause position (initial or final), and serial position of the target word within the clause (early (E) or late (L)). Eight groups of four subjects were randomly assigned to eight tape recorded lists of sentences; the tapes were balanced for main effects of the three independent variables, but not all possible treatment combinations occurred on each tape (i.e., clause type was combined with E only or L only in both clause orders so that one tape was the complement of another). To fully balance the design, each subject's two responses for a particular combination of independent variables (e.g., E, subordinate, initial) were averaged (where only one entry was available, it was used as the pair mean) and randomly paired with the appropriate mean response of another subject who had heard the complementary tape (e.g., L, subordinate, initial). As a result, there were 16 pair means in each condition.

Eight presentation lists were constructed. Each list consisted of only one sentence from each set. Within each half of a list there was an equal number of subordinate-main and main-subordinate test sentences and an equal number of occurrences of a target word in subordinate and main clauses for each clause order, with target words equally distributed across early and late positions by clause order but not clause type. Within these limits, test sentences were randomly ordered. An equal number of subordinate-main and main-subordinate filler sentences occurred in each half of the list, with an equal number of early, late, and not present target words. The order of test sentences and fillers was constant across the lists. In short, across the eight presentation lists sentence order remained constant, while clause type, clause position, and serial position of the target word within the clause varied.

Apparatus

The eight presentation lists were tape recorded by a male Standard American speaker. Fillers and test sentences were recorded on one channel in a monotone (an oscillator aided in keeping pitch constant) with an attempt to reduce clause boundary juncture. Sentences were recorded in this way to insure that subjects segmented the sentences according to syntactic knowledge rather than intonational cues. Probes were recorded on a second channel. The mean interval between the end of the last word of the test sentence and onset of the probe word was .327 seconds with a standard deviation of .100 seconds.

Sentences and probes were presented auditorally to subjects with a Tandberg series 12 tape recorder and stereophonic headphones. Onset of the probe activated a Grason-Stadler voice operated relay which started a Hunter millisecond timer. The subject's spoken response stopped the timer via microphone and a second voice operated relay.

Procedure

Subjects were tested individually. The subject heard a sentence immediately followed by a probe word. ~~Sentences and probes were dichotically presented.~~ Sentences were heard in the left ear and probes in the right ear. The subject was instructed to say "In" if the probe was present in the sentence and "Out" if it was not present, and to respond as rapidly and as accurately as possible. Reaction time was measured from the onset of the probe word to the subject's response.

Results

Of 256 data points, 18 errors and 3 missing data points were excluded from this analysis. Also, responses two standard deviations from a subject's mean for the test sentences were eliminated. Eleven responses were eliminated on this basis. An analysis of variance on reaction time as a function of clause type, clause po ition, and serial position of the target word within the clause was performed on the remaining data. The results of this analyis are shown in Table 1.

Insert Table 1 about here

Mean RT for E and L target words by clause position and clause type are presented in Table 2. A significant main effect was found for the

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Insert Table 2 about here

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clause position factor; mean RT for the target word within the final clause was .7705 seconds and mean RT for the target word in the initial clause was .9561 seconds ($F = 19.182$, $p < .001$, $df = 1/15$). Mean RT was significantly greater for initial clause probes than for final clause probes in seven of the eight test sentences. The interaction between serial position of the target word within the clause (E or L) and clause type (main or subordinate) was significant: Figure 1 shows that mean RT increased with serial position (a primacy effect) in subordinate clauses and mean RT decreased with serial position (a recency effect) in main

clauses ($F = 6.625$, $p < .025$, $df = 1/15$). A primacy effect was obtained

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Insert Figure 1 about here

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for subordinate clauses in five out of six and six out of eight test sentences for initial and final clause position, respectively. A recency effect was obtained for main clauses in six out of six and seven out of eight test sentences in initial and final clause position, respectively (response errors accounted for the missing sentences). An additional check of stimulus materials was made, since probe delays varied amongst sentences. The correleation coefficient was computed for probe delay by RT ($r = -.183$).

In short, if probes were in a subordinate clause, then early target words were recognized faster than late target words, regardless of whether the clause was in initial or final position in the sentence. If probes were in a main clause, then late target words were recognized faster than early target words, again regardless of whether the clause was in initial or final position in the sentence. For all levels of other factors, probes in final clauses were processed more quickly than probes in initial clauses. There were no additional significant main effects or interactions.

It is important to note that all reaction times two standard deviations or more from a subject's mean for the test sentences and all 18 errors (7% error rate) occurred with initial clause target words and none with final clause target words. The overall number of errors was

probably inflated (approximately 2%) by at least one probe word which was difficult to understand. For this reason and because the number of errors was small, no further analysis of errors was made.

It is concluded that a word's serial position within a clause, clause position, and clause type all influenced recognition latency for the words of a two-clause complex sentence in immediate memory. The findings of this study suggest that for a two-clause complex sentence in immediate memory, the clause functions as a perceptual unit; that sentence processing is carried out clause-by-clause; that the final clause is more readily available than the initial clause; and that the manner in which a clause is searched is related to the clause type.

Discussion

The finding in this study that a word in the final clause is recognized significantly faster than a word in the initial clause is consistent with the boundary effect found by Caplan (1971) and supports the serial clause search hypothesis proposed in this study. In addition, now it can be maintained with some confidence that the boundary effect is not an artifact of the manner in which within-clause search is carried out. The boundary effect cannot be attributed to the serial position of the target word within the clause, the number of perceptual units of the clause, the clause type, the clause order, the lexical function of the target word, the grammatical function of the target word, nor any interaction of these variables; these variables were either held constant or tested and showed no significnat main effect or significant interaction with clause position.

One might argue that the difference in recognition latency by clause position was not a boundary effect but was simply a recency effect, since this study confounded clause position with serial position of the target word within the sentence. However, a sheer recency effect explanation is contrary to the finding that for subordinate clauses mean RT increases with serial position. Also, Caplan (1971) demonstrated that serial position vis a vis the end of the sentence did not account for the boundary effect. Therefore, the data from this study support the boundary effect.

These results do not support the parallel clause search hypothesis. The parallel clause search hypothesis entails an increase in mean RT with serial position within the clause for both clause positions, regardless of clause type. The finding in this study that subordinate clauses produce a primacy effect and main clauses produce a recency effect, regardless of clause position, suggests that subordinate and main clauses are searched differently from one another and, therefore, supports the within-clause search hypothesis. It may be speculated that the difference in mode of search between main and subordinate clauses is related to the centrality or primacy of the main clause relative to the subordinate clause, i.e., it is suggested that main clauses exhibit a property of primacy over subordinate clauses.

The "dominance effect" reported by Kornfeld(Note 1), that mean RT was significantly faster for main-subordinate clause order than for subordinate-main clause order, is accounted for by the significant interaction between serial position of the target word within the clause and clause type. Kornfeld compared late, initial, subordinate

clause target words plus early, final, main clause target words (subordinate-main clause order) to late, initial, main clause target words plus early, final, subordinate clause target words (main-subordinate clause order; see sentences 2a - 2d). In this study, mean RT was computed for both early and late target word positions for both clause types in both clause positions, and no significant difference in mean RT by clause order was found. It may be noted that if only the positions tested by Kornfeld are abstracted from Table 2, then these data also give the result that mean RT for main-subordinate order was significantly faster than mean RT for subordinate-main order (mean RT for late, initial, subordinate plus early, final, main sentences was .89 seconds; and mean RT for late, initial, main plus early, final, subordinate sentences was .81 seconds, $t = 2.18$, $p < .05$, $df = 15$). Therefore, it appears that the "dominance effect" is an experimental artifact.

Finally, let us return to the original question of this study: How is the memory search of a two-clause complex sentence in immediate memory carried out? While a multiple storage model of sentence processing (Caplan, 1971) may account for the boundary effect, it fails to describe the difference in pattern of recognition latency between main and subordinate clauses; nor do any of the search models discussed account for all the data. Therefore, a combined storage-search account is suggested.

Storage-Search:

It is proposed that for a two-clause complex sentence in immediate

memory, the final and initial clauses are accessed in a serial self-terminating manner. The final clause is searched first; then the initial clause is searched. Upon finding a match between the probe and the target word, the search is terminated and a response is made (the serial clause search hypothesis). The subordinate clause in initial position and the main and subordinate clauses in final position are searched in a primary buffer; only the main clause in initial position is searched in a secondary buffer. Items in the primary buffer are more fully represented in memory than items in the secondary buffer and hence more readily available for retrieval than items in the secondary buffer (cf. Caplan, 1971; Jarvella & Herman, 1972). Depending upon the clause type, a procedure of search within the clause is employed (the within-clause search hypothesis). It may be speculated that either the words of the main clause are searched in parallel, with an increase in availability of words with serial position, or, alternatively, in a serial self-terminating manner counter to the order of presentation. The primacy effect found for subordinate clauses suggests that a serial self-terminating search in order of presentation may fit the subordinate clause data.

Storage-search$_1$ fits the following facts: (a) that mean recognition latency was shorter for the final clause than for the initial clause; (b) that the longest mean recognition latency for the final clause was less than the shortest mean recognition latency for the initial clause (see Table 2); (c) that a disproportionate number of errors and deviant reaction times were produced with initial clause target words compared

to final clause target words; (d) that main and subordinate clauses revealed different modes of search; (e) that the difference in RT between early and late target words was equal between subordinate clauses in initial and final clause position, but main clauses in initial position showed twice the within-clause difference in RT compared to main clauses in final position; (f) that recall for main clauses in initial position was significantly poorer than for main clauses in final position, but that subordinate clauses were recalled equally well in initial and final clause positions (Jarvella & Herman, 1972).

Storage-Search$_2$

Storage-search$_2$ differs from storage-search$_1$ only in its storage system. Storage-search$_2$ proposes that subordinate clauses are searched in a secondary buffer in both clause positions, but that main clauses are searched in a secondary buffer in initial position and in a primary buffer in final position. Storage-search$_1$ and storage-search$_2$ fit equally well with (a) - (f) above. However, if probability of recall is predicted on the basis of buffer location of memorized items, then storage-search$_2$ fits Jarvella and Herman's (1972) results better than storage-search$_1$. It accurately predicts that main clauses will be recalled better than subordinate clauses in final position but that in initial position recall between the clauses will not differ. Storage-search$_1$ makes the opposite predictions.

A parallel model of clause accessing proposes that the subject searches both initial and final clauses simultaneously. Final clauses

are searched faster than initial clauses because they are more strongly represented in memory or more fully represented. However, the claim that initial clause words enter the secondary buffer and final clause words enter the primary buffer, regardless of clause type, fails to account for (e) and (f) above and makes (b) less intelligible than with storage-search$_1$ or storage-search$_2$. Similarly, Caplan's (1971) proposed multiple perceptual storage system fails to account for (b), (e), and (f). Other multiple storage memory systems (Waugh & Norman, 1965; Glanzer, 1972) also fail to account for facts like (e) and (f) without elaboration. If the parallel model is modified to include the buffer systems of storage-search$_1$ or storage-search$_2$, it predicts that subordinate clauses will not show a difference in RT between clause position. With the buffer system of storage-search$_1$ the subordinate clause is searched in the primary buffer in both clause positions, and with the buffer system of storage-search$_2$ the subordinate clause is searched in the secondary buffer in both clause positions. Hence, a parallel model of clause accessing does not fit the evidence discussed here as well as a serial model of clause accessing.

The storage-search account raises a number of questions which require further research. Most obviously, is subordinate clause search serial, in order of presentation, and self-terminating? Is main clause search parallel with increasing availability of items, or serial self-terminating and counter to order of presentation? Also, in the present study it was not established whether primacy is a syntactic or a semantic property.

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Footnotes

[1]This research was carried out while I was a guest in T. G. Bever's laboratory at Columbia University. I am indebted to T. G. Bever for many hours of guidance and discussion, although I solely am responsible for any shortcomings in this paper.

[2]In addition, Caplan (1971, 1972) confounded lexical and syntactic function with serial position within the clause, clause position, and clause type--notice that "oil" is a noun in sentence 1a and an adjective in 1b, that "oil" is the object in 1a and part of the subject in 1b.

Table 1

Analysis of Variance

Source of Variation	SS	MS	DF	F
clause position (1st/2nd)	1.097236	1.097236	1	19.182**
clause type (M/S)	0.015029	0.015029	1	
serial position of target word (E/L)	0.009062	0.009062	1	
1/2 X M/S	0.006830	0.006830	1	
E/L X 1/2	0.016630	0.016630	1	
E/L X M/S	0.330993	0.330993	1	6.625*
E/L X M/S X 1/2	0.013510	0.013510	1	
Subjects (Ss)	1.694707	0.112980	15	
Ss X 1/2	0.858768	0.057251	15	
Ss X M/S	0.436585	0.029106	15	
Ss X E/L	0.176999	0.011800	15	
Ss X M/S X 1/2	0.277588	0.018506	15	
Ss X E/L X 1/2	0.234623	0.015642	15	
Ss X E/L X M/S	0.749376	0.049958	15	
Ss X E/L X M/S X 1/2	0.228963	0.015264	15	

* $p < .025$

** $p < .001$

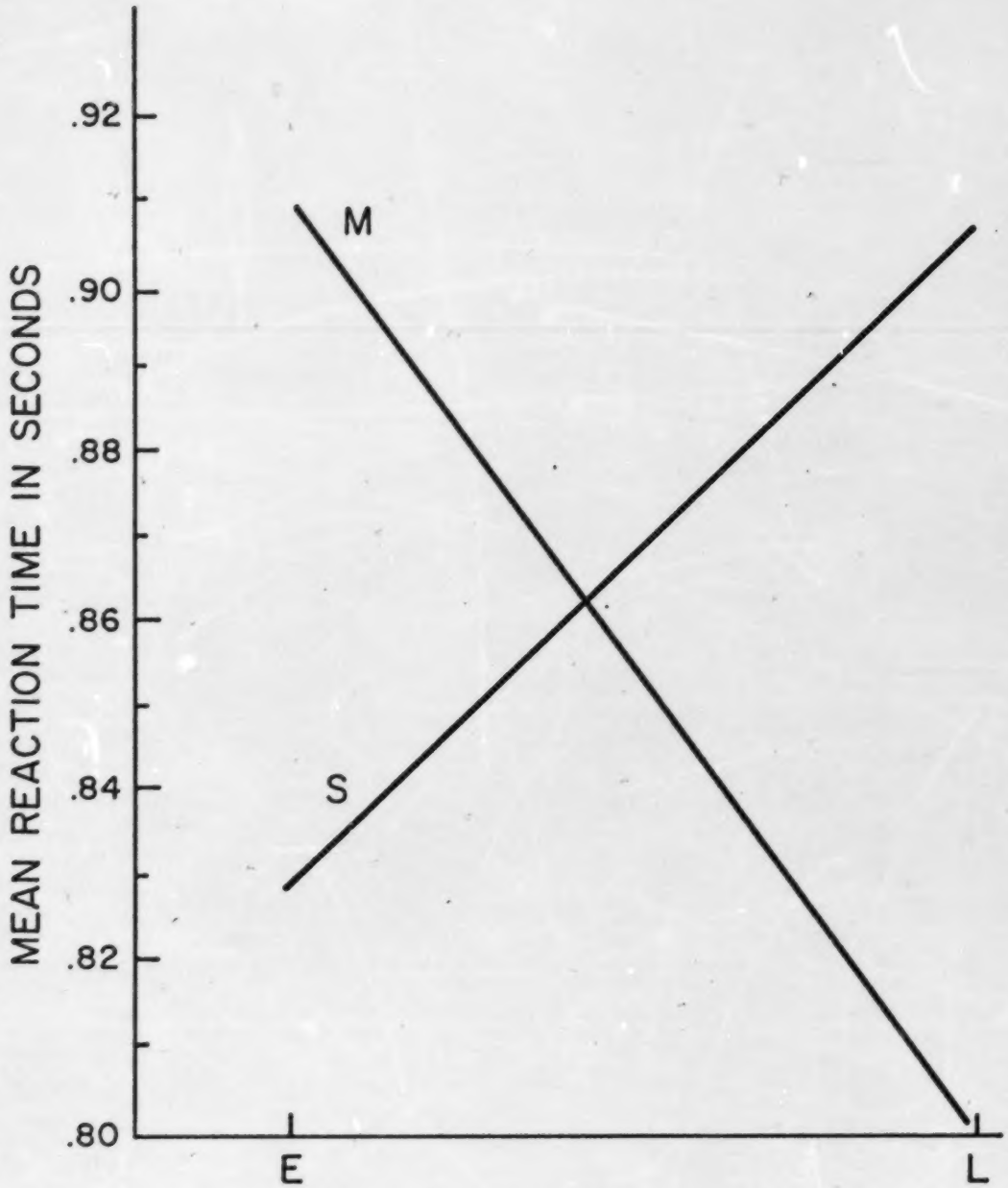
Table 2

Mean RT (in seconds) for E and L Target Items in Final and Initial Clause Position by Main and Subordinate Clause Type

Initial Clause				Final Clause			
Subordinate		Main		Subordinate		Main	
E	L	E	L	E	L	E	L
.9141	1.000	1.035	.8857	.7364	.8227	.7803	.7052

Figure Caption

Figure 1. Interaction between early versus late target word position and main versus subordinate clause type.


MEAN REACTION TIME IN SECONDS
.92
.90
.88
.86
.84
.82
.80
M
S
E
L

APPENDIX A

STIMULUS MATERIALS

Practice Sentences:

A considerable amount of time was lost, when Chuck broke his right arm. Considerable

Check all the fine print, before you sign a new lease. Sign

Even though the question is minor, think it through. Green

Successful businesses start up, when the government restricts imports. Restricts

No matter how much care you take, work clothes get dirty. Dirty

Eat more protein, if you want to gain more strength. Foot

Filler Sentences:

The committee unanimously agreed on adopting the new rule, after the the Congress openly argued about the issues. Openly

By making his plan known, Jim brought out the objections of everyone. Baby

After the dry summer of that year, most vegetable crops were ruined. Ruined

While John was patiently waiting for the doctor, he flipped casually through a magazine. Casually

It soon became obvious that our luck would not hold out. It

When Ralph's father decided to retire, he moved to the country to live. Train

While Peter took the garbage out to the incinerator, Henry started to put the model airplane together yesterday. Together

Blood stains stay in the fabric no matter how hard you try to clean it. Clean

What bothers old women shoppers most of all is that men ignore them. What

A fight did not immediately break out thank goodness, although the bully deliberately bumped into the little guy this morning. Deliberately

We bring liquor, every time we visit friends. Saw

You'll learn to like cheese when you go to France to live. Coat

After the teacher jokingly announced that there'd be a quiz, many students nervously glanced at one another. Nervously

The sun is out, although the forecast calls for more rain. Sun

No matter what the students say, they will all pass. Pass

We frequently argued about little things, after Tom, Bill, and Mary left our commune. Mary

Trees seem greener whenever it rains very hard. Skin

Although the patient now wants a cure, he must wait. Although

The new boy left quietly through a back door, because he felt comfortable with only one person in the room. Only

Fans go wild whenever this goalie stops the puck. Run

When management does not raise wages, strikes result. Cup

When the child spilled the milk accidentally on the floor, the puppy merrily waged his tail yesterday. Merrily

Serve good Scotch if you want friends to think you are rich. Rich

Though some disagreements still exist, peace is near. Yard

Experimental Sentences:

The man on the flying trapeze was the most breath taking act of all, though the trained bear and the clowns were fun to watch. Clowns

The man on the flying trapeze was the most breath taking act of all, though the clowns and the trained bear were fun to watch. Clowns

Though the man on the flying trapeze was the most breath taking act of all, the trained bear and the clowns were fun to watch. Clowns

Though the man on the flying trapeze was the most breath taking act of all, the clowns and the trained bear were fun to watch. Clowns

The trained bear and the clowns were fun to watch, though the man on the flying trapeze was the most breath taking act of all. Clowns

The clowns and the trained bear were fun to watch, though the man on the flying trapeze was the most breath taking act of all. Clowns

Though the trained bear and the clowns were fun to watch, the man on the flying trapeze was the most breath taking act of all. Clowns

Though the clowns and the trained bear were fun to watch, the man on the flying trapeze was the most breath taking act of all. Clowns

Though it was nice to speak often to you, the telephone bill was ridiculously high. Often

Though it was nice to often speak to you, the telephone bill was ridiculously high. Often

It was nice to speak often to you, though the telephone bill was ridiculously high. Often

It was nice to often speak to you, though the telephone bill was ridiculously high. Often

Though the telephone bill was ridiculously high, it was nice to speak often to you. Often

Though the telephone bill was ridiculously high, it was nice to often speak to you. Often

The telephone bill was ridiculously high, though it was nice to speak often to you. Often

The telephone bill was ridiculously high, though it was nice to often speak to you. Often

The large chair or the small couch must be moved, while the rest of the furniture can remain just where it is. Chair

The large couch or the small chair must be moved, while the rest of the furniture can remain just where it is. Chair

While the large chair or the small couch must be moved, the rest of the furniture can remain just where it is. Chair

While the large couch or the small chair must be moved, the rest of the furniture can remain just where it is. Chair

The rest of the furniture can remain just where it is, while the large chair or the small couch must be moved. Chair

The rest of the furniture can remain just where it is, while the large couch or the small chair must be moved. Chair

While the rest of the furniture can remain just where it is, the large chair or the small couch must be moved. Chair

While the rest of the furniture can remain just where it is, the large couch or the small chair must be moved. Chair

While the new girl was a whiz at reading, writing, and arithmetic, the new boy could not speak or write well. Speak

While the new girl was a whiz at reading, writing, and arithmetic, the new boy could not write or speak well. Speak

The new girl was a whiz at reading, writing, and arithmetic, while the new boy could not speak or write well. Speak

The new girl was a whiz at reading, writing, and arithmetic, while the new boy could not write or speak well. Speak

While the new boy could not speak or write well, the new girl was a whiz at reading, writing, and arithmetic. Speak

While the new boy could not write or speak well, the new girl was a whiz at reading, writing, and arithmetic. Speak

The new boy could not speak or write well, while the new girl was a whiz at reading, writing, and arithmetic. Speak

The new boy could not write or speak well, while the new girl was a whiz at reading, writing, and arithmetic. Speak

The clerk packed the beer, the coke, and the milk, while we decided on who would pay for the groceries. Beer

The clerk packed the coke, the beer, and the milk, while we decided on who would pay for the groceries. Beer

While the clerk packed the coke, the beer, and the milk, we decided on who would pay for the groceries. Beer

While the clerk packed the beer, the coke, and the milk, we decided on who would pay for the groceries. Beer

We decided on who would pay for the groceries, while the clerk packed the beer, the coke, and the milk. Beer

We decided on who would pay for the groceries, while the clerk packed the coke, the beer, and the milk. Beer

While we decided on who would pay for the groceries, the clerk packed the coke, the beer, and the milk. Beer

While we decided on who would pay for the groceries, the clerk packed the coke, the beer, and the milk. Beer

The boss came into the room, when Jack glanced quickly at the work he had done. Quickly

The boss came into the room, when Jack quickly glanced at the work he had done. Quickly

When the boss came into the room, Jack quickly glanced at the work he had done. Quickly

When the boss came into the room, Jack glanced quickly at the work he had done. Quickly

Jack glanced quickly at the work he had done, when the boss came into the room. Quickly

Jack quickly glanced at the work he had done, when the boss came into the room. Quickly

When Jack glanced quickly at the work he had done, the boss came into the room. Quickly

When Jack quickly glanced at the work he had done, the boss came into the room. Quickly

While the guests had cocktails in the living room, the cook sliced the bread and cut the steaks. Sliced

While the guests had cocktails in the living room, the cook cut the bread and sliced the steaks. Sliced

The guests had cocktails in the living room, while the cook cut the bread and sliced the steaks. Sliced

The guests had cocktails in the living room, while the cook sliced the bread and cut the steaks. Sliced

While the cook sliced the bread and cut the steaks, the guests had cocktails in the living room. Sliced

While the cook sliced the bread and cut the steaks, the guests had cocktails in the living room. Sliced

The cook slices the bread and cut the steaks, while the guests had cocktails in the living room. Sliced

The cook cut the bread and sliced the steaks, while the guests had cocktails in the living room. Sliced

Though Joe will come home soon to eat a hot meal, Barbra must rush off to her night shift at the hospital. Soon

Though Joe will soon come home to eat a hot meal, Barbra must rush off to her night shift at the hospital. Soon

Joe will soon come home to eat a hot meal, though Barbra must rush off to her night shift at the hospital. Soon

Joe will come home soon to eat a hot meal, though Barbra must rush off to her night shift at the hospital. Soon

Though Barbra must rush off to her night shift at the hospital, Joe will come home soon to eat a hot meal. Soon

Though Barbra must rush off to her night shift at the hospital, Joe will soon come home to eat a hot meal. Soon

Barbra must rush off to her night shift at the hospital, though Joe will come home soon to eat a hot meal. Soon

Barbra must rush off to her night shift at the hospital, though Joe will soon come home to eat a hot meal. Soon